Fact Sheet

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# Nuclear Fuel Facilities

**Background**

All commercial nuclear fuel facilities in the United States are required to be licensed or certified by the NRC. Fuel facilities are divided into three groups: those that involve the processing of uranium ore into uranium hexaflouride ($UF_6$); those that enrich the $UF_6$ in the $^{235}U$ isotope; and those that fabricate enriched uranium into nuclear reactor fuel. The names and locations of these facilities are listed below:

**Uranium Conversion**

Honeywell International, Inc. --------------------- Metropolis, IL

**Uranium Enrichment**

Paducah Gaseous Diffusion Plant ---------------- Paducah, KY
Portsmouth Gaseous Diffusion Plant ------------- Piketon, OH

**Nuclear Fuel Fabrication**

CE Nuclear Power, LLC --------------------------- Hematite, MO
Framatome-Cogema Fuels ------------------------- Lynchburg, VA
BWX Technologies, Inc. -------------------------- Lynchburg, VA
Global Nuclear Fuel-American, LLC ------------ Wilmington, NC
Nuclear Fuel Services ------------------------------ Erwin, TN
Siemens Power Corp. ------------------------------- Richland, WA
Westinghouse Electric Company LLC ----------- Columbia, SC

**Uranium Conversion**

Fuel facilities convert uranium to a form that is useful for producing energy in nuclear reactors. The extraction of uranium from ore results in yellowcake ($U_3O_8$) which is then converted into uranium hexafluoride. This material, which is produced in liquid form, is drained into 14-ton cylinders, where it solidifies into a crystalline form after cooling for approximately 5 days.

The most significant hazard at a uranium conversion facility is at the point in the process when liquid $UF_6$ is stored and processed. During a release of $UF_6$,it reacts with the moisture present in the surrounding air to form a dense vapor cloud that contains hydrogen fluoride (HF) gas, a non-radioactive substance that is extremely toxic. In 1986 at the Sequoyah Fuels Corporation conversion facility in Gore, Oklahoma, an overfilled cylinder of $UF_6$ ruptured, resulting in a major HF release that killed a worker. This facility was later closed by its owner.

**Uranium Enrichment**

The next stage in the production of nuclear fuel is the process used to enrich the uranium present in the $UF_6$. Uranium is primarily composed of two isotopes (i.e., $^{235}U$ and $^{238}U$). The $^{235}U$ isotope is what needs to be enriched (i.e., the percentage by weight increased) since it is fissile (capable of fissioning). Uranium enriched in $^{235}U$ is necessary in the commercial light water reactors used in the United States in order to produce a sustained and controlled nuclear reaction. The concentration of $^{235}U$ is enriched from the approximately 0.7% found in natural uranium to between 3 and 5% by mass for use in commercial reactors. Enrichments greater than 90% are used in the uranium fuel used in the U.S. Navy's nuclear propulsion reactors.

Currently, enriched uranium is produced in the United States using the gaseous diffusion process. Gaseous diffusion uses the separation effect of molecular effusion (i.e., the flow of gas through small orifices). In a vessel containing $UF_6$ gas, molecules of the gas with lower molecular weight ($^{235}U$) travel faster and strike the walls of the vessel more frequently, relative to their concentration, than do the molecules of the gas with higher molecular weight ($^{238}U$). If the walls of the vessel are permeable, more of the lighter molecules flow through the wall than the heavier molecules. The gas that escapes the vessel is thus slightly enriched in the lighter isotope. Such vessels are connected in strings of hundreds (or even thousands) called a cascade, and each pass through a vessel enriches the $UF_6$ a little more. The final enrichment of $UF_6$ in the $^{235}U$ isotope can be controlled by bleeding off the $UF_6$ at various points along the cascade.

There are two gaseous diffusion plants currently operating in the United States, one at Piketon, Ohio, and the other at Paducah, Kentucky. Both plants are operated by the United States Enrichment Corporation (USEC) under leases with the U.S. Department of Energy. The Energy Policy Act of 1992 established USEC and authorized NRC to regulate the operational health and safety aspects of the gaseous diffusion plants. In accordance with that Act, NRC promulgated regulations for the gaseous diffusion plants in 10 CFR Part 76 in September 1994. NRC certified that the plants met the requirements in Part 76 in late 1996. After certification, the two plants came under NRC regulation on March 3, 1997. [Additional information on these plants can be found in the Technical Issue paper (#30) on gaseous diffusion plants].

There are other enrichment technologies available. One technology is the gas centrifuge process, which uses the principle of centrifugal force to separate a gas containing components of different molecular weights. A gas centrifuge is a hollow vertical cylinder (i.e., rotor) that is spun about its axis at high speed that causes heavier molecules to move closer to the outer wall of the centrifuge while the lighter molecules concentrate near the cylinder axis. The enriched and depleted gases can be withdrawn using stationary tubes located within the rotor.

An additional enrichment technology is the Atomic Vapor Laser Isotope Separation (AVLIS) process. AVLIS involves the use of high-energy lasers to separate vaporized $^{235}U$ from $^{238}U$ and process it into enriched uranium fuel. This process uses precisely tuned, high-powered lasers to selectively photoionize $^{235}U$ atoms by removing one of its electrons. These positively charged $^{235}U$ ions are then electrically separated from the rest of the feed material. The result is two product streams of uranium metal, one enriched in $^{235}U$ and the other depleted.

The gas centrifuge and AVLIS processes are not currently used to produce commercially available enriched uranium in the U.S. In fact, the AVLIS process has not yet been demonstrated to be commercially viable.

Since the enrichment facilities handle and process large amounts of $UF_6$, the same chemical hazards present at a uranium hexafluoride conversion facility are also present at an enrichment facility. In addition, the production of special nuclear material (i.e., enriched uranium) at enrichment facilities constitutes a criticality hazard. (Criticality, in this context, is defined as an inadvertent nuclear chain reaction.) A criticality may release large, localized amounts of radiation that can be harmful and even fatal to personnel and may be damaging to process equipment as well. The special nuclear material also requires that significant measures be taken to safeguard such material against theft or diversion, as well as to prevent unauthorized enrichment.

**Nuclear Fuel Fabrication**

Fabrication is the final step in the process used to produce uranium fuel. This process converts enriched $UF_6$ into a solid form of uranium suitable for use in a nuclear reactor. Nuclear fuel must maintain both its chemical and physical properties under the extreme conditions of heat and radiation present inside an operating reactor vessel. Fabrication of light water reactor fuel consists of three basic steps: the chemical conversion of $UF_6$ to uranium dioxide ($UO_2$) powder; the ceramic process that converts $UO_2$ powder to pellets; and the mechanical process that loads the fuel pellets into rods and constructs finished fuel assemblies.

For light water reactor fuel, after the $UF_6$ is chemically converted to $UO_2$ powder, the powder is blended, milled, pressed, and sintered into ceramic fuel pellets. The pellets are placed in tubes made of suitable materials (e.g., zirconium alloys) called cladding and, after careful inspection, the resulting fuel rods are assembled into fuel assemblies for use in reactors. The cladding material separates the pellets from the reactor coolant while providing one, of multiple, barriers to contain the fission products produced during the nuclear chain reaction. Following final assembly operations, the completed fuel assembly is washed, inspected, and finally stored in a special rack until ready for shipment to a nuclear power plant site.

Fuel fabrication facilities have essentially the same types of hazards as enrichment facilities (i.e., radiological, chemical, and criticality hazards). Fuel fabrication facilities must also guard against the loss, theft, and diversion of special nuclear material.

**Regulations**

The regulation of commercial nuclear fuel facilities is primarily the responsibility of the NRC, although these facilities are also subject to applicable requirements of the Occupational Safety and Health Administration and the Environmental Protection Agency. The objectives of NRC regulations are to protect the health and safety of the public and plant workers and the environment from radiological and certain chemical hazards present at fuel cycle facilities. In addition, for those facilities that store or process special nuclear material, the NRC requires that facilities safeguard such material from loss, theft or diversion.

**Current Status**

The larger fuel fabrication facilities, both gaseous diffusion plants, and the uranium hexafluoride conversion facility continue to operate and produce nuclear fuel under licenses or certificates issued by NRC. NRC frequently inspects these facilities and has resident inspectors at the BWX Technologies, Inc., facility, the Nuclear Fuel Services facility, and USEC's two gaseous diffusion plants.

Several other nuclear fuel cycle facilities have ceased operations and are currently undergoing decommissioning. These include the following:

General Atomics facility in San Diego, California;
ABB Prospects, Inc. in Windsor, Connecticut;
Sequoyah Fuels Corporation in Gore, Oklahoma;
Cimmaron Corporation in Cimmaron, Oklahoma; and
Babcock & Wilcox facility in Parks Township, Pennsylvania.

The operating fuel fabrication facilities have also been remediating portions of their facilities by removing or stabilizing radioactive contamination present at their sites in areas that are no longer in use.